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INSTRUCTIONAL SYSTEMS DEVELOPMENT
DECISION SUPPORT

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SUMMARY

This paper describes the scope and definition of the ISD process and the decision support features incorporated in the Joint Service Instructional Systems Development/Logistic Support Analysis Record Decision Support System (ISD/LSAR DSS). In the DSS, six ISD procedures are supported with decision aids: Task Selection for Training, Learning Objectives Analysis, Instructional Setting Selection, Instructional Sequencing, Training Media Selection, and Training Equipment Requirements Analysis. The paper describes how the six ISD decision aids provide the required decision flexibility, improve information accessibility, produce meaningful results for a range of user experiences/levels/responsibilities, provide graphic displays, permit "what if...?" analyses, and facilitate system use. Each decision aid is described by identifying its primary users, the decisions it supports, and by giving a description of its operation.

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PREFACE

This technical paper is a basic overview of the ISD decision support features developed for two ongoing Department of Defense sponsored programs to integrate training systems development with other weapon system design activities. The Training System for Maintenance (TRANSFORM) is an Air Force program that provided the initial research and development platform for the ISD procedure specific to the analysis process of the Air Training Command. Subsequent to that prototype development, the Joint Service Instructional System Development/Logistic Support Analysis Record Decision Support System (DSS) was designed using TRANSFORM as the foundation. The DSS provides powerful advantages in performing effective training analysis by reducing analysis subjectivity, improving process consistency and quality, improving decision flexibility, and saving time.

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ISD DECISION SUPPORT

I. INTRODUCTION

This paper describes the decision support features incorporated in the Joint Service Instructional Systems Development/Logistic Support Analysis Record Decision Support System (ISD/LSAR DSS). The Joint Service ISD/LSAR DSS is a major DoD effort to integrate training system development with other weapon system design activities. The system's key feature, its automated LSAR-to-ISD data interface, permits an ISD analyst to maintain consistency with the evolving weapon system design and supportability characteristics recorded in the LSAR. The decision support techniques employed by the Joint Service ISD/LSAR DSS improve and standardize ISD decision making by providing users with appropriate and consistent presentations of LSAR and other training-related data.

A thorough ISD analysis of training system requirements draws heavily from pertinent existing data to support a variety of analysis decisions. Depending upon the analysis situation and the required analysis detail, there may be thousands of decisions that ISD analysts must make. Assembling data to support each ISD analysis decision is a monumental task that can be aided by automation. However, decision support is much more than a data handling exercise. The value of decision support stems from its ability to improve the effectiveness of decision making. Decision support fosters a synergistic decision making process that improves the quality of decisions made.

In the Joint Service ISD/LSAR DSS, six ISD procedures are supported with decision aids: Task Selection for Training, Learning Objectives Analysis, Instructional Setting Selection, Instructional Sequencing, Training Media Selection, and Training Equipment Requirements Analysis. The paper describes how the six ISD decision aids provide the required decision flexibility (including adaptive decision making over time), improve information accessibility, produce meaningful results for a range of user experience levels/responsibilities, provide graphic displays, permit "what if ...?" analyses, and facilitate system use. Each decision aid is described by identifying its primary users, the decisions it supports, and by giving a description of its operation. Where appropriate, assessments of quantitative and qualitative improvements in ISD decision outcomes are provided.

II. THE JOINT SERVICE ISD/LSAR DSS

Instructional Systems Development (ISD) (Department of the Air Force, 1979; Department of the Army, 1988; Department of the Navy, 1981; US Marine Corps, 1986) is a systems approach to training analysis. The ISD process consists of a structured sequence of analytical steps that determine weapon system training design requirements. Performing an ISD analysis of a weapon system can be a slow, labor-intensive process requiring extensive manual data manipulation.

Logistic Support Analysis (LSA) is an iterative process that regularly updates a weapon system's design and supportability information through all

acquisition phases. The LSA Record (LSAR) is the repository for LSA results. However, neither the LSA process nor the LSAR database is tailored to provide information to the ISD process. As a result, using LSAR data to support ISD is currently a difficult and time-consuming procedure.

For emerging weapon system designs, ISD could significantly benefit from the extraction of tasks and other weapon system data using an automated interface with the LSAR. The Joint Service ISD/LSAR Decision Support System (DSS) combines automated ISD analysis procedures with an automated LSAR data interface. Using the ISD/LSAR DSS, LSAR data are extracted in a structured way to meet the data requirements of the ISD analysis. DSS' automated ISD procedures accommodate service-specific and situational (e.g., front-end ISD analysis, training problem analysis, etc.) analysis requirements (Main and Paulson, 1988).

III. LSAR DATA PRESENTATIONS

Military Standard (MIL-STD) 1388-2A (Department of Defense, 1986), 20 July 1984, prescribes the data element definitions, data field lengths, and data entry requirements for LSAR data. The Joint Service ISD/LSAR DSS uses data from LSAR A, B, C, D, E, F, and G records contained in two LSAR master files: the LSA Control Number (LCN) Master File and the Task Narrative Master File. The training data elements listed in Table 1 are used to support the DSS training analyses. The data elements are listed by data element definition (DED) number.

Meaningful presentations of LSAR training-related data support the analyst in performing ISD analyses and in making effective ISD decisions. The DSS uses LSAR data in one of two ways. First, LSAR data that describe a weapon system's equipment structure, task hierarchy, and task performance requirements provide the ISD analysis structure used by the DSS. The ISD analyst uses these LSAR data to construct the DSS subsystem, task, task element, skill/knowledge hierarchy. Relationships between MIL-STD 1388-2A key data elements (LCN/ALC, task code, and sequential line number) are preserved so that DSS data structures correspond with LSAR data organization.

The second use of LSAR data within the DSS are presentations of data to support specific ISD decisions. As an example, Figure 1 displays LSAR data that may aid the ISD analyst in providing the required DSS input related to one task selection criterion.

IV. TRAINING ANALYSIS DECISION SUPPORT

The value of decision support stems from its ability to improve the effectiveness of decision making. Decision support fosters a synergistic decision making process that improves the quality of decisions made. The decision support features in the Joint Service ISD/LSAR DSS consist of an interactive human/machine interface that facilitates the user's reasoning process.

Six decision support features are included in the Joint Service ISD/LSAR DSS. Table 2 summarizes the decision support characteristics applicable to the design and operation of each DSS decision support feature. The decision support characteristics listed on Table 2 are defined as follows:

Table 1. LSAR Training Data Elements

| <u>LSAR DED</u> | <u>DATA ELEMENT</u> |
|-----------------|---|
| 002 | ACCESSIBILITY |
| 010 | ADDITIONAL-SKILL-REQUIREMENT |
| 011 | ADDITIONAL-SKILLS-AND-SPECIAL-TRAINING-REQUIREMENTS |
| 013 | ADDITIONAL-TRAINING-REQUIREMENTS |
| 023 | ALTERNATE-LCN-CODE |
| 027 | ANNUAL-NUMBER-OF-MISSIONS |
| 028 | ANNUAL-OPERATING-DAYS |
| 029 | ANNUAL-OPERATING-REQUIREMENTS |
| 052 | CARD-SEQUENCING-CODE |
| 053 | CIVILIAN-GRADE |
| 101 | DUTY-POSITION-REQUIRING-NEW/REVISED-SKILL |
| 103 | EDUCATIONAL-QUALIFICATION |
| 106 | END-ITEM-ACRONYM-CODE |
| 115 | FACILITIES-REQUIREMENTS |
| 121 | FAILURE-DETECTION-METHOD |
| 122 | FAILURE-DETECTION-METHOD-CODE |
| 128 | FAILURE-MODE-INDICATOR |
| 152 | HARDNESS-CRITICAL-ITEM |
| 153 | HAZARDOUS-CRITICAL-PROCEDURES |
| 155 | HAZARDOUS-MAINTENANCE-PROCEDURES-CODE |
| 175 | ITEM-CATEGORY-CODE |
| 181 | ITEM-NAME |
| 183 | JUSTIFICATION |
| 197 | LOGISTIC-SUPPORT-ANALYSIS-CONTROL-NUMBER |
| 204 | MAINTENANCE-CONCEPT |
| 205 | MAINTENANCE-EASE |
| 220 | MEASURED-MEAN-MAN-HOURS-PER-SKILL-SPECIALTY |
| 223 | MEAN-MAN-MINUTES |
| 232 | MEAN-MINUTE-ELAPSED-TIME |
| 234 | MEAN-MISSION-DURATION |
| 242 | MEANS-OF-DETECTION |
| 244 | MEASUREMENT-BASE |
| 246 | MILITARY-RANK |
| 269 | NUMBER-OF-PERSONS-PER-SKILL-SPECIALTY-CODE |
| 285 | OPERATIONAL-REQUIREMENT-INDICATOR |
| 288 | OPERATIONS/MAINTENANCE-LEVEL |
| 313 | PERFORMANCE-STANDARDS |
| 316 | PERSON-IDENTIFIER |
| 319 | PHYSICAL-AND-MENTAL-REQUIREMENTS |
| 354 | QUANTITY-PER-TASK |
| 372 | REFERENCE-NUMBER |
| 394A | FACILITIES-REQUIREMENTS-CODE |
| 394B | TRAINING-EQUIPMENT-REQUIREMENTS-CODE |
| 394C | TOOL/SUPPORT-EQUIPMENT-REQUIREMENT-CODE |

TABLE 1 (Cont'd)

| <u>LSAR DED</u> | <u>DATA ELEMENT</u> |
|-----------------|--|
| 399 | SECURITY-CLEARANCE |
| 403 | SEQUENTIAL-INSERTION-LINE-NUMBER |
| 406 | SEQUENTIAL-LINE-NUMBER |
| 410 | SEQUENTIAL-TASK-DESCRIPTION |
| 422 | SKILL-LEVEL-CODE |
| 423 | SKILL-SPECIALTY-CODE |
| 424 | SSC-ASSIGNED-NEW-DUTY-POSITION |
| 433 | SKILL-SPECIALTY-EVALUATION-CODE |
| 434A | SSC-FROM-WHICH-PERSONNEL-CAN-BE-OBTAINED |
| 434B | SSC-FROM-WHICH-PERSONNEL-CAN-BE-OBTAINED |
| 451 | SUBTASK/TASK-ELEMENT-CODE |
| 457 | SUPPORT-EQUIPMENT-REQUIRED |
| 467 | TASK-CODE |
| 468 | TASK-CONDITION |
| 469 | TASK-CRITICALITY |
| 470 | TASK-FREQUENCY |
| 472 | TASK-IDENTIFICATION |
| 473 | TASK-ID-CODE |
| 479 | TECHNICAL-MANUAL-CODE |
| 489 | TEST-SCORE |
| 502 | TRAINING-LOCATION-RATIONALE |
| 503 | TRAINING-RATIONALE |
| 504 | TRAINING-RECOMMENDATION |
| 524 | UNIT-OF-MEASURE |
| 544 | WORK-AREA-CODE |

TASK ELEMENTS FOR TRAINING

IATE-TRNG

WS: C7 SSC: 112X0
 SS: C45A AUX POWER SYSTEM
 TASK: BGOFBAA TEST SYSTEM HYD POWER, AUXILIARY

| TASK ELEMENT | | N | C | C | N | T | I |
|--------------|--|---|---|---|---|---|---|
| ID NUMBER | TASK ELEMENT DESCRIPTION | W | D | R | X | E | O |
| 001 | PREPARE TO PERFORM AUXILIARY (AUX) HYDRAULIC (HYD) SYSTEM TEST | | | | | | |
| 005 | CHECK HYD PRESSURE ON EFFECTED SYSTEM HYD PRESSURE DISPLAY | | | | | | |
| 007 | OBSERVE RESERVOIR FLUID OVER TEMPERATURE LAMPS ARE NOT ILLUMINATED | | | | | | |

Figure 1. LSAR Data In Support Of ISD Task Element.

IATE-TRNG TASK ELEMENTS FOR TRAINING

EXPLANATION OF INDIVIDUAL QUESTIONS

Is this task element new to the SSC? (NW)

- This question may be rephrased to: Does the target population perform this task element?

Are conditions associated with performing this TE abnormal or special? (DC)

- This question refers to any environmental limitations under which the task element must be performed. Examples include limited access environment, excessive noise, cramped working conditions, safety hazards, and extreme component size or weight.

Are there new or unusual criteria related to this task element? (CR)

- New or unusual criteria may refer to new or stricter standards of performance in speed, timing, accuracy, sequence, etc.

Is there a chance for negative transfer to occur? (NX)

- Negative transfer occurs when the target population performs this task element in a manner previously learned that may result in incorrect or possibly dangerous results.

Decision Support System Characteristics

| Training Analysis Decisions | Decision Support System Characteristics | | | | | |
|--|---|------------------------------------|---------------------------|---------------------------------|--------------------------|-------------|
| | Decision Flexibility | Adaptive Decision Making Over Time | Information Accessibility | Output for Multiple User Levels | "What If... " Capability | Ease of Use |
| Task Selection for Training | X | X | X | X | X | |
| Learning Objectives Analysis | | | X | X | X | |
| Instructional Setting Selection | | X | X | | | X |
| Instructional Sequencing | X | X | X | X | X | X |
| Training Media Selection | X | X | X | X | | |
| Training Equipment Requirements Analysis | X | X | X | X | X | X |

Table 2. ISD/LSAR DSS Training Analysis Decision Support Characteristics

Are new or modified support tools or equipment required? (TE)

- If new or modified support tools or equipment are required, the target population may be required to learn new skills or knowledges.

Integrate Only (IO)

Decision Flexibility. Ability to change decision parameters to meet a variety of analysis needs and situations.

Adaptive Decision Making Over Time. Ability to develop new decision models/methodologies to allow the user to refine and improve the decision process.

Information Flexibility. Ability to access information sources and determine applicability to the ISD analysis.

Output for Multiple User Levels. Will support the information needs of weapon system planners and ISD analysis management as well as the ISD analysts.

"What if ...?" Capability. Ability to vary decision parameters and rapidly display and evaluate the decision results.

Ease of Use. Ability of an unskilled user to operate the decision support feature and produce a high quality decision.

Each decision support feature is presented below. The feature is described by identifying the decisions the feature supports, a description of its operation, and a discussion of the feature relative to the six characteristics of decision support systems.

V. TASK SELECTION FOR TRAINING

The ISD analyst identifies all the tasks that warrant training. The task selection process requires a series of user decisions: choosing a task selection model, assigning model criteria weights and a task selection cutoff value (if required by the model), supplying data and expert judgments required as input to the model, and evaluating the model recommendations. Analysts are also provided the option of constructing a task selection criterion. The four task selection models available to DSS users are:

The 3306th Test and Evaluation Squadron (TES) Task Selection Procedure
(Procedures Manual: 3306th Test & Evaluation Squadron, 1987)
Eight Factor Model (Department of the Army, 1979)
Four Factor Model (Department of the Army, 1979)
Difficulty, Importance, and Frequency (DIF) Model (Department of the Army, 1980)

The 3306th TES procedure results in a train/no-train decision; with the other models, numerical ratings for tasks are computed automatically in response to ISD analyst input for task selection criteria.

The ISD/LSAR DSS Task Selection for Training decision support procedures provide:

Decision Flexibility

- A range of task selection models
- Construction of unique task selection models

Adaptive Decision Making Over Time

- Revision of constructed task selection models to adapt to analysis situations or make better use of available task data

Information Accessibility

- Displays LSAR data pertinent to user decisions (e.g., making subjective judgments about task difficulty, task criticality, etc.)
- Queries to extract task lists sorted on one or more task selection criteria

Output for Multiple User Levels

- Task selection reports for analysts
- Task selection criteria reports for management review of analysis approach

"What if ...?" Capability

- Comparisons of results from alternative task selection models
- Ability to view the impact of altering task selection criteria weights and cutoff values

VI. LEARNING OBJECTIVES ANALYSIS

The ISD analyst develops learning objective (LO) hierarchies consisting of terminal LOs (TLOs) and LOs. The analyst may then identify a key word for each TLO/LO that maps to a selection of learning taxonomies. The learning taxonomies currently used by the DSS are those of Bloom et al. 1956; Gagne, 1985; Krathwohl, et al. 1964; Simpson, 1972.

The DSS supports the ISD analyst in developing LO hierarchies, identifying TLO and LO key words, and selecting learning taxonomies for learning objectives analysis.

The ISD/LSAR DSS Learning Objectives Analysis decision support procedures provide:

Output for Multiple User Levels

- Results used in subsequent ISD analysis steps, particularly training sequencing and course structuring

"What if ...?" Capability

- Comparison of results using alternative learning taxonomies

VII. INSTRUCTIONAL SETTING SELECTION

One or more instructional settings are identified for each weapon system task to be trained. There are five possible instructional setting outcomes: Job Performance Aids (JPAs), Self-Teaching Exportable Packages (STEPs), Formal On-The-Job Training (FOJT), Installation Support Schools (ISSs), and Resident

Schools (RSs). Tasks are first clustered based upon conditions and constraints that strongly influence or control the selection of instructional setting: (1) skill level or rank of the trainee, (2) the need for special training facilities, (3) the need for special training equipment, (4) special personnel needs for training, and (5) other training constraints identified by the analyst. The ISD analyst is assisted in forming task clusters and then is guided to the selection of an instructional setting for each weapon system task or task cluster.

The ISD/LSAR DSS Instructional Setting Selection decision support procedures provide:

Information Accessibility

- Displays LSAR and condition, cue, and standard (CCS) data to assist in forming task clusters
- Queries to extract weapon system task lists sorted on one or more clustering criteria

Output for Multiple User Levels

- Task clusters to facilitate instructional setting selection
- Instructional setting reports for analysts
- Instructional setting criteria reports for management review
- Cluster criteria for use in course structuring
- Instructional settings as an early indication of training resource requirements

Ease of Use

- Well-structured procedure to help the analyst assign large numbers of tasks to instructional settings

VIII. INSTRUCTIONAL SEQUENCING

The DSS user is supported in sequencing learning to maximize training efficiency and effectiveness. Four sequencing parameters are used to perform an initial gross sort of tasks or learning objectives: task action type (repair, remove and replace, inspect, etc.), equipment to which tasks are related, task maintenance level, and learning objective. An automated learning objectives analysis model, using the analyst-selected learning taxonomies (listed above in the Learning Objectives Analysis procedure), supports sequencing approaches that include the learning objective parameter. The ISD analyst refines the gross instructional sequence based upon the degree to which tasks/learning objectives are deemed to be independent, dependent, or supportive of other tasks/learning objectives.

The ISD/LSAR DSS Instructional Sequencing decision support procedures provide:

Decision Flexibility

- Various combinations of sequence parameters
- Tasks or learning objectives sequenced

Information Accessibility

- Different gross sorts of tasks/learning objectives may be viewed before refining the instructional sequence

Output for Multiple User Levels

- Gross instructional sequence presented to analyst for refinement
- Sequencing criteria reports for management review of analysis approach

"What if ...?" Capability

- Comparisons of results from alternative sequencing approaches (parameter combinations)

Ease of Use

- Ability to sequence large number of tasks/learning objectives with minimal additional input

IX. TRAINING MEDIA SELECTION

The ISD analyst is supported in making initial training media decisions, analyzing training media alternatives, and establishing a decision audit trail with which to update the training system as the weapon system design changes. The media selection process requires a series of user decisions: choosing a media selection model, selecting and appropriately weighing model criteria, constraining model outcomes if desired, supplying data and expert judgments required as input to the model, and evaluating the model recommendations (Gagne, et al. 1981; Heinich, et al. 1989; Kemp and Dayton, 1985; Romiszowski, 1988). (Model outcome constraints may be directly identified by DSS users or be those automatically imposed by previously identified instructional settings.) Analysts are also provided the option of constructing a media selection model. The media selection models available to DSS users are:

The 3306th Test and Evaluation Squadron (TES) Media Selection Procedure Automated Instructional Media Selection (AIMS) Model (Kribs, et al. 1983)

The 3306th TES media selection is performed at the task element or skill/knowledge level; the other model performs media selection for learning objectives or tasks. Appropriate LSAR data and prior ISD decision results are presented to the ISD analyst to support subjective judgments required by media selection logic.

The ISD/LSAR DSS Training Media Selection decision support procedures provide:

Decision Flexibility

- A range of media selection models
- Media selection performed for either learning objectives or task structure
- Construction of unique media selection models
- Ability to tailor models to consider training media constraints

Adaptive Decision Making Over Time

- Revision of constructed media selection models to adapt to analysis situations or make better use of available task/learning objective data

Information Accessibility

- Displays LSAR and other ISD data to support subjective user decisions

Output for Multiple User Levels

- Media selection reports for analysts
- Media selection criteria reports for management review of analysis approach

"What if ...?" Capability

- Comparisons of results from alternative media selection models
- Ability to view the impact of selecting alternate media selection parameters or alternately weighing the parameters
- Ability to view differences between constrained and unconstrained model applications

X. TRAINING EQUIPMENT REQUIREMENTS ANALYSIS

The ISD analyst identifies hardware components that are crucial to the learning process and determine how they are to be represented on training devices. DSS prompts the user to identify and evaluate components for all subsystems requiring hardware training media. Automated decision logic generates physical and functional fidelity requirements for components of each identified training device (Hays and Singer, 1989; Hritz and Purifoy, 1980).

The ISD/LSAR DSS Training Equipment Requirements Analysis decision support procedures provide:

Decision Flexibility

- Operates at the task element or learning objectives level

Information Accessibility

- Displays LSAR equipment/component data for analyst reference

Output for Multiple User Levels

- Input to training device functional descriptions

"What if ...?" Capability

- Ability to view the impact of modifying component fidelity criteria

Ease of Use

- Consolidated fidelity recommendations (across tasks, lessons, blocks, and courses) generated automatically for each training device

XI. SUMMARY

The Joint Service ISD/LSAR DSS decision support features offer potential advantages in performing effective training analyses:

Reduced Analysis Subjectivity. By providing on-line access to LSAR data and preceding ISD decisions, training analyses may be better integrated with other, concurrent analytical activities. Additionally, automated ISD procedures could reduce the number of unstructured analyst judgments.

Improved Process Consistency and Quality. By incorporating standardized, Service-accepted training analysis logic, the ISD/LSAR DSS should improve the ability to produce repeatable analysis results and results that are strongly supported by prevailing educational theory.

Decision Flexibility. By permitting ISD/LSAR DSS users to construct and tailor tools for performing training analyses, ISD decision making across the range of expected ISD analysis situations can be supported.

Time Savings. The ISD/LSAR DSS provides an effective way to use LSAR data to support training analyses. The reduction in LSAR data handling time may be significant.

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